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Socioeconomic Determinants of Stunting According to Country Income Grouping: Panel Data Analysis

Wilson Rajagukguk¹, Omas Bulan Samosir², Perak Samosir³, Swanto Sirait⁴, Anthony Tampubolon⁵,
Frencky Sitorus⁶, Ruth Natasha⁷

¹ Universitas Kristen Indonesia. Email: Wilson.rajagukguk@uki.ac.id; wrajagukguk@yahoo.com

² Universitas Indonesia. Email: omas.bulan@ui.ac.id; omasbr@yahoo.co.uk

³ Institut Teknologi Indonesia. Email: samosirperak@gmail.com

⁴ Universitas Kristen Indonesia. Email: Email: suwanto.sirait@uki.ac.id

⁵ Universitas Kristen Indonesia. Email: antonitampubolon@gmail.com

⁶ Universitas Kristen Indonesia

⁷ Universitas Bunda Mulia, Indonesia. Email: rnattasha@bundamulia.ac.id

Correspondence: Wilson Rajagukguk. ORCID ID: <https://orcid.org/0000-0002-5802-609X>

Abstract

Stunting remains a global problem that needs to be addressed, not only in low- and middle-income countries but also in high-income countries. Goal 2 of Sustainable Development Goals 30 aims to create a world free from hunger by 2030 (UN, 2015). This study was conducted to identify the determinants of stunting in countries stratified by income. Data were obtained from the World Bank Indicator (2026), categorizing countries by income into low-income, lower-middle-income, upper-middle-income, and high-income groups. The analysis method used was linear regression with panel data. The time period covered the study was 2005–2024. The analysis showed that access to electricity, access to clean fuels and cooking technologies, women's business, and the Law Index Score (scale 1–100) were associated with reduced stunting. Meanwhile, the variables carbon intensity of GDP (kg CO₂e per 2021 PPP \$ of GDP) and unemployment (% of total labor force) increased stunting prevalence.

Keywords: Stunting, Socioeconomic Determinants, Country Income Grouping, Panel Data Analysis

1. Background

Goal 2 of Sustainable Development Goals 30 is to achieve a world free from hunger by 2030 (UN, 2015). Global hunger and food insecurity have shown an alarming increase since 2015, a trend exacerbated by a combination of factors including the pandemic, conflict, climate change, and deepening inequalities. Stunting is impaired growth and development in children due to chronic (long-term) malnutrition and repeated infections. It is characterized by a child's height being shorter than expected for their age, reflecting growth failure that can impact brain development, intelligence, and the risk of future disease. This condition occurs primarily during the First 1,000 Days of Life (HPK), from conception to age 2, and is triggered by inadequate nutritional intake, poor parenting practices, and poor environmental sanitation.

Stunting is a major challenge to global health. Stunting is characterized by impaired growth and development in children due to prolonged malnutrition, affecting physical height and cognitive abilities. Malnutrition refers to insufficient or excessive nutrient intake, an imbalance in essential nutrients, or impaired nutrient utilization. The double burden of malnutrition comprises undernutrition, overweight and obesity, and diet-related non-communicable diseases. Malnutrition manifests in four main forms: wasting, stunting, underweight, and micronutrient deficiencies (WHO, 2026). Acute malnutrition (wasting) is defined as low weight for height. It often indicates recent and severe weight loss, although it can also be prolonged.

When a person does not receive adequate food quality and quantity and/or they are frequently or chronically ill, acute malnutrition in children is associated with a higher risk of death if not properly treated. Stunting is defined as low height for age. It results from chronic or recurrent malnutrition, usually associated with poverty, poor maternal health and nutrition, frequent illness, and/or inadequate feeding and care early in life. Stunting prevents children from reaching their physical and cognitive potential. Underweight is defined as low weight for age. Children who are underweight may experience stunted growth, acute malnutrition, or both (WHO, 2026).

Micronutrient deficiencies are deficiencies in vitamins and minerals essential for bodily functions such as producing enzymes, hormones, and other substances needed for growth and development.

This condition is common in developing countries and is a direct result of inadequate nutritional intake from conception through the first 1,000 days of life, including the prenatal period (Rokom, 2023).

The impact of stunting is its impact on individual health, as well as cognitive abilities, educational performance, and future economic productivity. Stunted growth early in life leads to chronic health problems in adulthood and an increased risk of non-communicable diseases. Stunting also has social consequences, such as stunted growth, which perpetuates the cycle of poverty and reduces economic progress at the national level.

The World Health Assembly (WHA) targets a 40% reduction in stunting prevalence by 2025 compared to 2013 levels. Furthermore, the Sustainable Development Goals (SDGs) target is to eliminate all forms of malnutrition by 2030. The 78th World Health Assembly (WHA) in 2025 extended the global nutrition target to 2030, aiming to reduce the number of children under five years old who experience stunting by 40%. This updated goal aligns with the SDGs to combat malnutrition, which require intensive investment to reduce the global prevalence of stunting, which has fallen from 26.4% in 2012 to 23.2% in 2024 (WHO, 2025b).

Figure 1 shows the trend of stunting prevalence, height for age (% of children under 5) in four groups of countries according to income level in the period 2005 - 2025. The highest prevalence of stunting is in low-income countries, followed by lower-income countries, and the upper-middle-income group of countries. In these three income groups, there was an improvement, namely a decrease in the trend of prevalence of stunting, height for age (% of children under 5). Meanwhile, in high-income countries, the prevalence of stunting was already at around 5% and the situation tended to stagnate during the study period.

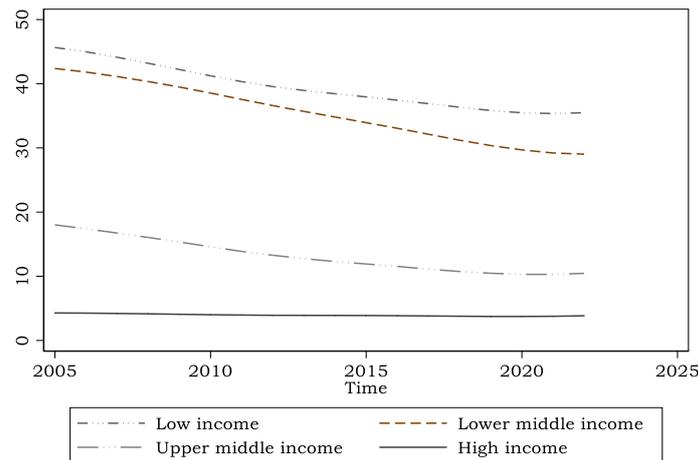


Figure 1: Prevalence of stunting, height for age (% of children under 5)

Source: World Bank (2026), own calculation

At the 78th World Health Assembly (WHO, 2025b), WHO Member States agreed and adopted a resolution extending the Global Nutrition Targets for improving maternal, infant, and early childhood nutrition from 2025 to 2030. The four agreed targets are: (1) a 40% reduction in the number of children under five who experience stunting, (2) a 50% reduction in anemia in women of reproductive age, (3) a 30% reduction in low birth weight, and (4) a reduction in acute malnutrition in children under five to less than 5%.

Furthermore, this study was conducted to examine the socioeconomic and demographic determinants of stunting in countries by income group. Income groups are divided into four groups: high-income, upper-middle-income, lower-middle-income, and low-income.

2. Literature Review

The factors causing stunting are multifaceted, including diet quality, disease burden, and broader socioeconomic conditions. Linear growth in children is stunted when diet quality is poor or when children are frequently exposed to infections, particularly during the critical period before the age of two. Diet composition, particularly including animal-source foods during complementary feeding, plays a crucial role in providing the dense and bioavailable nutrients necessary for optimal growth.

By 2023, new electricity connections will outpace population growth, increasing global access to 92 percent and reducing the number of people without electricity to 666 million—19 million fewer than the previous year. The remaining unconnected population tends to live in remote areas, have lower incomes, and face challenges of vulnerability, conflict, and violence (IEA, 2025).

Chronic child malnutrition remains a critical global public health challenge, influenced by complex interactions between biological, socioeconomic, and environmental factors (Yani et al. 2023). Specifically, household electricity availability has been identified as a key infrastructure variable that facilitates efficient resource utilization for child care and is associated with a reduced likelihood of chronic malnutrition (Pillai and Maleku 2019; Utumatwishima et al. 2023). The relationship between electrification and child nutritional status has not been widely explored in the literature.

Fujii, T., Shonchoy, A. S., & Xu, S. (2018) offer microeconomic evidence from rural Bangladesh. They found that the rapid expansion of electrification and significant improvements in nutritional status observed over the past two decades are used. The results indicate that access to electricity has the potential to improve children's nutritional status through various pathways, such as increased well-being, reduced birth rates through changes in

time-use patterns, the dissemination of information through technologies such as television, and improved health services. Improved child nutrition has a direct impact on reducing stunting.

The World Health Organization defines clean fuels and technologies as those that meet recommended levels of fine particulate matter and carbon monoxide, including solar, electricity, biogas, natural gas, liquefied petroleum gas, and alcohol fuels such as ethanol (Khamjalas 2024). Several studies on the relationship between access to clean cooking fuels and technologies (percentage of population) and stunting have shown a significant impact on stunting reduction (WHO, 2023, ScienceDirect, 2024), Eduvest (2024), and Wiley Online Library (2020).

Rahma & Hartono, D. (2024) conducted research in Indonesia on the impact of clean cooking fuel use on the risk of stunting in children aged 0–59 months. Using cross-sectional data from the 2014 Indonesian Family Life Survey (IFLS) and the Propensity Score Matching (PSM) method, they found that households using clean cooking fuels, such as liquefied petroleum gas (LPG), significantly increased children's Height-for-Age Z-scores, which in turn increased the risk of stunting. This study highlights the importance of clean energy policies and increased awareness, particularly in rural areas, for reducing health disparities and improving child growth outcomes. These findings contribute to the growing body of evidence linking clean energy transitions to improved public health and child development indicators.

Tang et al., (2024) conducted a study on the nutritional impact of non-solid cooking fuel use on children under five years of age in developing countries. Using data from over 1.12 million children in 62 developing countries from the Demographic and Health Survey (DHS) and using fixed effects (FE) and instrumental variable estimation methods, it was shown that the use of non-solid cooking fuels significantly improves the nutritional outcomes of children under five years of age. Compared to their peers from households that predominantly use solid fuels, children from households that predominantly use non-solid fuels showed a lower probability of stunting (by 5.9 percentage points) and being underweight (by 1.2 percentage points).

Evidence also suggests that this occurs through several mechanisms, such as improved indoor air quality, reduced respiratory symptoms in children, benefits for maternal health, and reduced time mothers spend collecting fuel or cooking.

GDP carbon intensity (kg CO₂e per 2021 PPP GDP) measures greenhouse gas emissions (CO₂, methane, nitrous oxide, etc.) from the agriculture, energy, waste, and industry sectors—divided by 2021 gross domestic product in constant purchasing power parity (PPP) dollars.

Countries that successfully reduce the carbon intensity of their economies while maintaining growth are better able to address environmental and public health challenges, including reducing child stunting (Perissi and Jones, 2022).

Masters et al. (2022) conducted research on the impact of carbon intensity on stunting prevalence. The policy proposal is that economic development and environmental characteristics (such as carbon intensity) can create a foundation for improvements in health infrastructure and resource availability. Well-targeted policies and interventions are needed to translate these macro-level changes into tangible reductions in stunting prevalence.

Women's autonomy and bargaining power can be used to measure the broader context that influences child health outcomes. Indicators of women's bargaining power include participation in decision-making about household spending and autonomy in healthcare decisions. The Women's Business and the Law Index Score is relevant for understanding the pathways through which the Women's Business and the Law Index Score can influence child health and nutrition, including reducing stunting in children. The Women's Business and the Law Index Score shapes women's roles in household decision-making and access to resources. (Hossain and Nikolov, 2021)

The Women's Business and the Law Index Score can be a determinant of increased employment opportunities for women. Women's employment opportunities can change the dynamics of household income and bargaining

power within the household. When women have greater control over resources and decision-making, they tend to prioritize spending that benefits children's health and nutrition, leading to health improvements, including reduced stunting (Masters et al. 2022).

Unemployment and stunting are closely linked through the cycle of poverty, where a lack of employment opportunities—particularly for mothers—correlates with poor nutrition and, conversely, where stunting limits human capital and future economic productivity.

Wulandari et al. (2025) found that children of unemployed mothers had a higher risk of stunting (1.022 to 1.07 times greater) compared to children of employed mothers, largely due to lower household incomes and reduced access to quality nutrition in Indonesia.

Marini et al. (2025) conducted research in Indonesia and found that unemployed mothers had a 2.364 times higher risk of having stunted children compared to employed mothers. Maternal education and employment status were identified as risk factors for stunting

3. Data and Analysis Methods

3.1. Data

The data in this study are taken from the World Development Indicators (World Bank, 2025). The dependent variables used are stunting prevalence, height-for-age (modeled estimates, % of children under 5 years), and the independent variables are country groups by income, time, access to electricity (% of population), access to clean fuels and cooking technology (% of population), GDP carbon intensity (kg CO₂e per 2021 PPP \$ GDP), Women's Business and Legal Index score (scale 1-100), and unemployment, total (% of total labor force) (modeled using ILO estimates). Table 1 describes the data used in the study.

Table 1: Variable, Obs., Mean, Std. Dev., Min, and Max

Variable	Obs.	Mean	Std. Dev	Min.	Max
Prevalence of stunting, height for age (modeled estimate, % of children under 5)	72	22.98	15.26	3.74	45.65
Access to electricity (% of population),	72	77.18	28.04	20.92	99.98
Access to clean fuels and technologies for cooking (% of population),	72	57.93	33.07	12.03	99.98
Carbon intensity of GDP (kg CO ₂ e per 2021 PPP \$ of GDP),	72	.23	0.099	.103	.432
Women Business and the Law Index Score (scale 1-100),	72	69.53	9.58	50.32	86.98
Unemployment, total (% of total labor force)	72	62.02	3.16	56.02	67.28

3.2. Analysis Method

The GLS Random Effects analysis method was used for panel data regression.

The panel regression equation can be written as follows:

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \dots + \beta_k X_{kit} + \epsilon_{it}$$

where Y_{it} : The dependent variable on individual i at time t

α : Constant or intercept

β_1, \dots, β_k : Regression coefficient (slope) for independent variables 1 to k
 X_{1it}, \dots, X_{kit} : Independent variables at individual i and time t
 ϵ_{it} : Error component (residual)

4. Analysis Results

The results of the regression analysis using panel data are presented in Table 2.

Access to electricity has a positive impact on health. Every 1% increase in the population with access to electricity reduces the prevalence of stunting in children under 5 by 0.351.

Every 1% increase in access to clean fuels and cooking technologies reduces the prevalence of stunting in children under 5 by 0.132 percent.

Every one-unit increase in GDP carbon intensity (kg CO₂e per 2021 PPP \$ of GDP) increases the prevalence of stunting in children under 5 by 14.426 percent.

Every one-unit increase in the Women's Business and the Law Index Score (scale 1-100) is associated with a 0.292 percent decrease in the prevalence of stunting in children under 5.

Every 1% increase in unemployment is associated with a 0.256 percent increase in the prevalence of stunting in children under 5.

The more developed a country is in terms of income, the lower the prevalence of stunting. This is in accordance with the results presented in Figure 1. According to time, worldwide from 2006 there was a downward trend until 2010, then in the period 2011 – 2024 there was an upward trend.

Table 2: Variable, Coef., Std. Err., Z, P>z, and 95% Conf. Interval]

Variable	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval]	
Access to electricity (% of population),	-.351	-.15.97	-15.97	0.000	-.394	-.307
Access to clean fuels and technologies for cooking (% of population),	-.132	.0117	-11.22	0.000	-.155	-.109
Carbon intensity of GDP (kg CO ₂ e per 2021 PPP \$ of GDP),	14.426	2.149	6.71	0.000	10.213	18.639
Women Business and the Law Index Score (scale 1-100),	-.292	.087	-3.35	0.001	-.121	-.121
Unemployment, total (% of total labor force)	.256	.086	2.95	0.003	.085	.426
Time: 2006	.357	.236	1.51	0.131	-.105	.819
2007	.666	.285	2.33	0.020	.106	1.226
2008	.669	.347	1.93	0.054	-.010	1.349
2009	.659	.413	1.59	0.111	-.151	1.470
2010	.634	.459	1.38	0.167	-.265	1.535
2011	.676	.495	1.36	0.173	-.295	1.640
2012	.842	.544	1.55	0.122	-.225	1.910
2013	1.271	.621	2.04	0.041	.0522	2.489
2014	1.614	.670	2.41	0.016	.300	2.927
2015	1.961	.735	2.67	0.008	.519	3.40
2016	2.619	.802	3.26	0.001	1.045	4.192
2017	2.910	.861	3.38	0.001	1.221	4.599
2018	3.242	.931	3.48	0.000	1.417	5.068
2019	3.568	1.016	3.51	0.000	1.575	5.560
2020	3.608	1.044	3.45	0.001	1.560	5.656
2021	4.151	1.096	3.79	0.000	2.002	6.300

2022	4.883	1.185	4.12	0.000	2.559	7.207
Country: low income	-.1321	.0117	-11.22	0.000	-.155	-.109
lower income	14.426	2.149	6.71	0.000	10.213	18.639
upper middle income	-.292	.087	-3.35	0.001	-.121	-.121
High income	.256	.0869	2.95	0.003	.085	.426
constant	60.84	3.978	15.30	0.000	53.048	68.642

Wald chi2(25) = 168546.56, corr(u_i, X) = 0 (assumed), Prob > chi2 = 0.0000

Source: world Bank (2026). Own calculation

5. Conclusions/Findings and Policy Recommendations

Stunting remains a global development concern. The prevalence of stunting is not limited to low- and middle-income countries, but also continues to occur in high-income countries. Globally, stunting tends to increase between 2011 and 2024.

This study provides policy recommendations for countries, governments, and stakeholders to intervene in stunting through development initiatives such as increasing access to electricity, access to clean fuels and cooking technologies, the Women's Business and the Law Index Score (scale 1-100), and reducing the variables Carbon Intensity of GDP (kg CO₂e per 2021 PPP \$ of GDP) and Unemployment (% of total labour force).

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